RECENT ADVANCES IN INLAND AQUACULTURE IN INDIA

V. G. JHINGRAN[1]

(*With five plates*)

The inland aquaculture resources of India are estimated as 1.6 million ha of freshwater ponds and tanks, 2.0 million ha of brackish-water lagoons and impoundments, 0.72 million ha of natural lakes and 2.0 million ha of man-made reservoirs. India is perhaps one of the few countries in the world which have vast inland aquaculture resources. Unfortunately, a significant part of this potential resource is unutilized and even the part that is in use is under-utilized. The contribution of inland fish production in India is about 40% of the total fish production of the country, of which at least 50% is contributed by aquaculture resources alone. It is unfortunately not realised that the potentials of aquaculture resources are so great that, if properly developed and exploited, these could contribute 15 to 16 times more than their present yield. In the following pages I outline some of the important achievements in inland aquaculture in India in the last few years.

1. Fry/fingerling production

The first research programme undertaken after independence was increasing the survival rate of spawn and fry of cultivable carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) during their nursing. The mortality rate of spawn in nursery ponds was as high as 97% which was almost reversed as a result of detailed researches conducted at the Central Inland Fisheries Research Institute and a survival of about 50% made easily possible under field conditions with the application of the newly developed techniques. Further improvements have been effected in the technology in recent years. The rate of stocking in nursery ponds initially was 1 million spawn/ha which has now been increased to ten times, i.e. 10 million/ha. The concept of well-manured, predator—and weed-free, nurseries, with abundance of natural fish food (zooplankters) which is simultaneously supplemented by protein rich organic feed of vegetable origin, has been developed. Great emphasis is now laid on the water quality (pH, DO, ammonia, alkalinity, phosphates and nitrates). Despite such a high rate of stocking, a survival of over 66% is possible with the addition of cobalt (0.01 mg/fish/day) in the feed. This technological development enables production of a very large number of fry/unit area which is especially advantageous in view of the paucity of nursery space in the country.

Similarly, the development of a three-tier system of culture, i.e. growing the fry obtained from nursery into another set of ponds called rearing ponds, before finally stocking them in larger water sheets for production of table-sized fish has proved itself to be greatly advantageous in handling the young ones and increasing survival rates. Fingerling rearing techniques have been developed and a survival of over 80% is now obtained in such operations when the stocking density is as high as 350,000 fry/ha. A 3-month rearing gives a

[1] Director, Central Inland Fisheries Research Institute, Barrackpore.

crop of fingerlings which in terms of weight is of the order of 3,000 kg/ha, each individual fish growing to 100-150 mm which is a suitable size for stocking larger sheets of water. A survival of over 90% from well-prepared stock ponds can be expected in all cases where large-sized fingerlings are stocked.

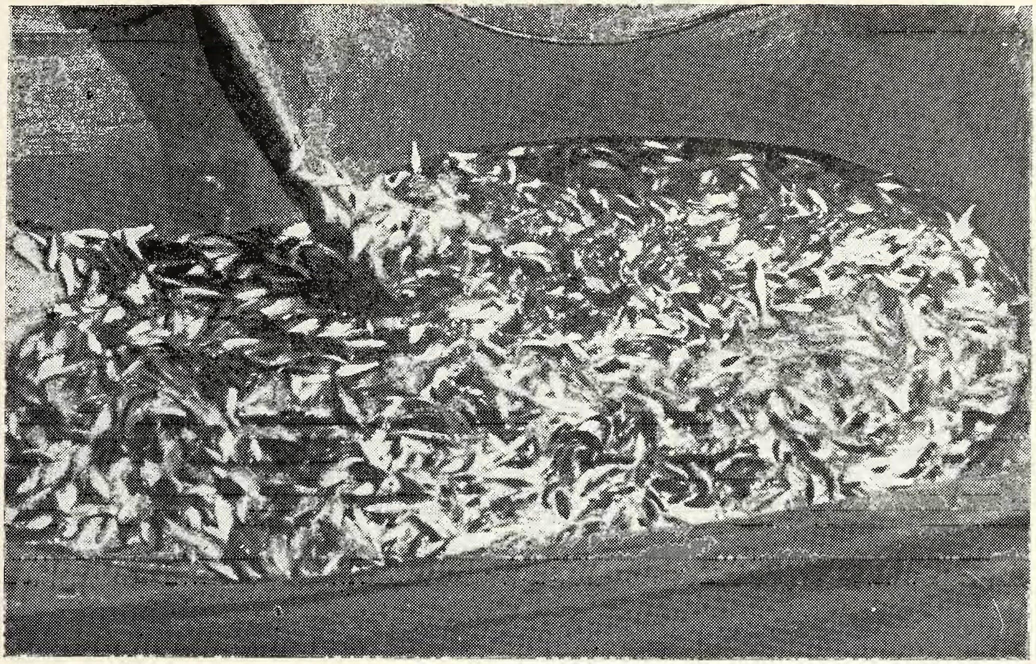
2. **Pond preparation**

Considerable work had to be done during the course of rearing experiments on developing the techniques of pond preparation and fertilization. As the import of derris-root powder, which was used as a fish toxicant for eradication of predatory and weed fishes at the research farms, was stopped, the need to find a suitable indigenously available substitute was felt. A large number of plant toxins were screened and the root and bark of *Barringtonia acutangula,* seed of *Milletia pachycarpa* and *M. piscida,* and *Croton tiglium* found quite effective. However, non-availability of these products on a commercial scale resulted in the popularisation of the use of mahua oilcake (*Bassia latifolia*), despite its requirement in large quantities as an efficient piscicide at 2,500 kg/ha-meter and a longer detoxifying period. The fish killed by the application of mahua oilcake is fit for human consumption unlike certain chemical piscicides. Ammonia (15 ppm N) too is an effective piscicide, weedicide and a nitrogenous fertiliser.

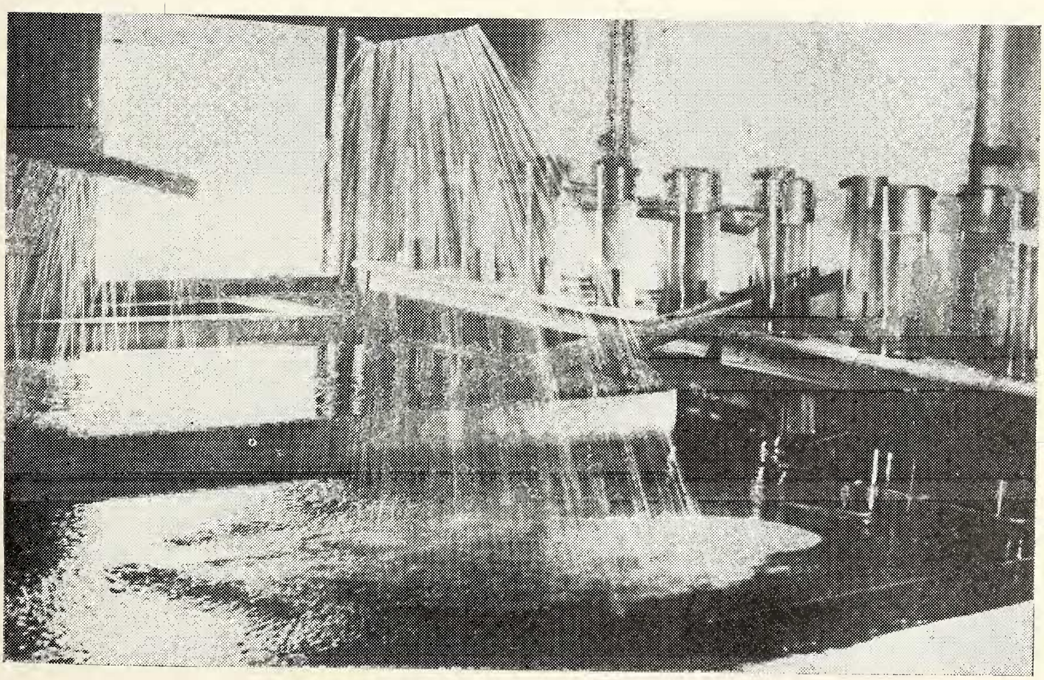
Studies on the effect of various types of organic and inorganic fertilizers and their dosages indicated that an application of universally available cowdung at 10,000 - 20,000 kg/ha results in an abundant growth of fish food organisms in nursery, rearing and stock ponds. In acid soils, this application is preceded by treatment with lime at 300 kg/ha. Use of poultry manure has been found to be very effective and much smaller quantities than cowdung constitute an effective dose. In recent years, utilization of inorganic fertilisers has also found a place in pond preparation. Urea for slightly acidic to neutral and ammonium sulphate for alkaline soils are suggested for pond preparation. Calcium-ammonium nitrate is another suitable fertiliser for acid soils which provides both calcium and nitrogen at the same time. For stock ponds, liming followed by an initial high dose of cowdung (5,000-10,000 kg/ha) or mahua oilcake (2,500 kg/ha-m) followed subsequently by alternate application of inorganic and organic fertilisers every month is generally recommended in systematic freshwater carp culture.

3. **Fish breeding**

The cultivable carps of India namely catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) breed annually in flooded rivers and contiguous fields during the monsoon months. Naturally, these resources therefore constitute the collection grounds for the young ones of these species. Natural collections from the rivers and flooded fields are but a mixture of both desirable and undesirable species of fish as most of the predatory and weed fishes also breed during the same season. This results not only in wastage during collection but also during subsequent handling, rearing and transport where the undesirable fish seed is either responsible for large-scale predation or competition for food, space and oxygen. It was, therefore, necessary to develop a technique whereby the cultivable carps could be bred exclusively for their seed and at will. The practice of breeding these fishes at will by creating semi-natural conditions is already known for a long time in certain districts of Bengal and Bihar. This technique,



A haul of fingerlings.



Glass Jar hatchery.
(*Photos*: Author)

Bumper catch from a composite fish culture Pond.

Haul of healthy magur fed on dried marine trash fish.
(*Photos*: Author)

known as *bundh* breeding, has now been considerably improved and extended to various parts of the country.

However, of the two types of *bundhs*, wet and dry depending upon the availability of water either throughout or a part of the year, the dry type yield better quality seed and are more dependable than the wet ones. The general unsuitability of the site and construction, maintenance and operation costs have been the main impediments in the multiplication of *dry* bundhs in seed production. The technique, wherever possible, is certainly advantageous for mass production of fish seed and has also been successfully used for experimental spawning of the Chinese major carps (grass carp and silver carp) which are now in great demand in India.

An important landmark in the history of freshwater aquaculture research and development has been the spawning of cultivable fishes by administration of fish pituitary gonadotropins known as induced breeding or hypophysation. The technique of induced breeding was first developed in India in 1955 and not only the indigenous carps but also the exotic carps as well as several species of catfishes, air-breathing fishes and mullets can now be spawned within a 2 × 1 × 1 m box-like cloth chamber, *hapa*, fixed half or three-fourths submerged in water. Mature males and females when injected with the pituitary gland extract, ovulate and spermiate either naturally or by application of gentle pressure on the abdomen of the brood fish after a lapse of a few hours of injection. The dosages for the different species have been standardised and the technique is increasingly being used for the production of fish seed for aquaculture in the country.

The techniques for hatching the eggs were also very poor and generally resulted in heavy mortality. However, the use of double-walled cloth *hapas* (the outer one of muslin cloth and the inner one of round-meshed mosquito netting) which is a sort of an open box within a box, has helped in increasing the hatching and the survival rate of the young hatchlings. Yet another development during the last five years has largely done away with the vagaries of nature as the *hapas* have to be fixed in ponds where high temperatures, heavy winds or fluctuating water levels, algal blooms, crabs and trash fish, generally create havoc resulting in mass mortalities or poor survival. The new technique makes use of continuously running water through a series of glass jars, where the eggs are kept, virtually buoyant, and provided with sufficient aeration. The hatchlings, drifting out through the jar spout on to an open conduit, are collected in a separate receptacle where again a continuous shower provides adequate aeration. Since the glass jar hatchery is put on land under a shed, the field hazards to which *hapas* are exposed are largely done away with as also the recurring expenditure on cloth *hapas* which hardly last a season.

4. Composite fish culture

Considerable attention has been paid in recent years to increase the per hectare production of table fish from stock ponds. Experiments in this direction conducted from the early sixties initially gave productions of 3,000-4,000 kg/ha/yr. However, in course of time further experimentation resulted in higher and higher rates of fish production so much so that production as high as over 9,000 kg/ha/yr was obtained in experimental ponds. This technology involving the use of indigenous (*C. catla, L. rohita* and *C. mrigala*) and exotic (*Ctenopharyngodon idella, Hypophthalmichthys molitrix* and *Cyprinus carpio*) major carps coupled with a set of management practice is termed as composite fish culture. Stocking densities from 3,000 to 10,000 fingerlings/ha have been used and densities around 5,000 to 7,500 fingerlings/ha found easily manageable. As in the case of nursery and rearing ponds, the concept of well-manured, predator-free ponds with a natural abundance of fish food organisms is also the rule in composite fish culture. In order to achieve high productions, periodic fertilisation of the ponds and daily feeding of fish with supplementary food items like groundnut oilcake and rice bran (1 : 1) at 2-3% of the body weight of the fish stock is necessary. The various species stocked in the pond are so proportioned that the natural food is utilised without much competition between the different species. These proportions have been carefully worked out in the course of a decade of experimentation. Surface feeders (catla and silver carp) constitute about 35%, followed by mid-feeders (rohu and grass carp) which account for about 30%. The bottom feeders (mrigal and common carp) constitute another 35%. Since silver carp feeds on the primary producers (phytoplankton) which are always in a greater abundance than the secondary producers (zooplankton), a higher percentage of silver carp (25%) than catla (10%) is stocked in a pond. Of the mid-feeders, rohu browses on a wide variety of planktonic algae and organic debris and constitutes 20% of the stock as against grass carp which forms 10% of the total density. As grass carp can be raised on aquatic or land weeds resulting in economy of supplementary feed, a variety of aquatic or land vegetation, cattle fodder and various vegetable wastes, are provided in a floating enclosure in the pond for its consumption. Supplementary feed in the form of a dough is provided on feeding trays, hung ½ to 1 m below the water surface, only after the grass carp are satiated. The bottom feeders, mrigal (15%) and common carp (20%), obtain their natural feed from the bottom detritus, decaying organic matter and semi-digested faecal matter passed out by the voraciously feeding grass carp. The unutilised faecal matter of grass carp acts as a fertiliser. This synergistic equation is the crux of composite fish culture.

5. Domestic sewage/livestock wastes as fish pond fertilisers

The practice of utilising domestic sewage for fertilising fish ponds is in vogue in several parts of the world and also in India around Calcutta for a very long time. Domestic wastes are available in every village, town and city. They pose a great problem in large cities and are discharged into the river courses which they pollute causing considerable damage to the total aquatic life in general and fishes in particular. Use of this waste is aptly made by its introduction, either as such in the raw form, or after dilution or as a supernatant effluent after initial settlement, in large ponds. This is one of the cheapest and the richest fertiliser for fish ponds. Alternately, fish ponds afford one of the simplest and cheapest means of abating pollution due to domestic sewage. The wastes are recycled in ponds and high quality fish protein obtained. Rates of fish production are also high without the use of supplementary feed in this system of culture. Productions as high as 9,350 kg/ha/yr of *Tilapia mossambica* have been obtained from ponds irrigated by sewage effluents. A production of 7,200 kg/ha/yr has been obtained by carp culture in these ponds. A very high stocking density is also possible because of the abundance of the natural fish food organisms and their repeated regeneration. However, oxygen deficiency and high BOD occasionally cause a havoc resulting in mass mortality in such ponds. Diseases due to parasites are also a common feature. One has, therefore, to be extremely careful while utilising sewage effluents for fish ponds.

Use of cattle / poultry / duckery / piggery wastes is also made in fish ponds. However, the techniques for their use are not yet standardised in India and attempts in this direction are being made at the Central Inland Fisheries Research Institute. Preliminary results on the use of wastes from pig-sties and duck-houses have resulted in high fish production without fertilization and feeding. This has a great future for India as the feed costs in composite fish culture account for about 50% of the total expenditure.

6. New systems of culture

Some catfishes and air-breathing fishes are in great demand in certain parts of India. However, there has been no systematic culture of these species until recently. Early attempts made to culture murrels (*Channa* sp.) resulted in a failure. In recent years, attempts to develop a new system of culture—air-breathing fish culture/catfish culture—have been made. The important air-breathing species such as singhi (*Heteropneustes fossilis*), magur (*Clarias batrachus*) and murrels (sal, saul and lata, *Channa* sp.) are now being cultured in swamps, derelict waters, freshwater ponds and cages in both swamps and freshwater ponds. As the air-breathing species can withstand poor oxygen conditions swamps and derelict waters can be conveniently used for their culture. This is just one way of utilising the abandoned waters in the country. The techniques of mass breeding the air-breathing species by hypophysation have been perfected and the dosages utilising the carp pituitary for the purpose standardised. The difficulties in hatching and rearing the young ones have also been surmounted by use of nylon *hapas* which prevent the entry of macroscopic planktonic forms known to be preying on tiny hatchlings while, at the same time, allowing a free exchange of water. Supplementation both by choice food organisms and artificial feed comprising boiled egg powder further helps in increasing the survival rate of the young ones.

The greatest difficulty experienced in the past while culturing these either carnivorous or piscivorous species was the provision of large quantities of living organisms or fishes throughout the year in culture ponds. This has been solved outright by providing a diet of dry, marine trash fish to the fingerlings of these species on which they feed avidly and grow well and fast. A production of 5,000 kg/ha/5 months of magur and 4,042 kg/ha/7 months of sal (*Channa marulius*) has been obtained under the new systems of culture in swampy and derelict ponds. Magur and singhi have also been cultured in freshwater ponds in combination with carps or without them. A production of 1,200 kg of magur/ha/4½ months was obtained from a small shallow pond under carp culture, the contribution of carps being 2,108 kg/ha/9½ months.

Cage culture of singhi and lata (*C. punctatus*) has also been done and a production of 9 kg/m²/7 months and 5.2 kg/m²/6 months respectively has been obtained. The fish in these cages have been fed on a mixture of cowdung + silkworm pupae + oilcake. Cage culture of singhi in carp ponds and magur culture in ponds with water changing facilities are presently being experimented with for high yields.

7. Control of aquatic weeds and their recycling

Of the four methods of weed clearance *viz.*

manual, mechanical, chemical and biological, biological methods are the cheapest. A weed-eating fish of Chinese origin *viz.* grass carp (*Ctenopharyngodon idella*) was introduced in India in 1957 along with a planktivorous fish *viz.* silver carp (*Hypophthalmichthys molitrix*) for biological control of higher aquatic weeds and algal blooms respectively. While it has been possible to control submerged and floating weeds of various types by introduction of grass carp in various water sheets, silver carp has not proved useful in the control of algal blooms in fish ponds. A lepidopteran insect larva (*Erastroides curvifascia*) has been recently discovered to be a potent biological control agent for the effective control of the floating weed, *Pistia stratiotes.*

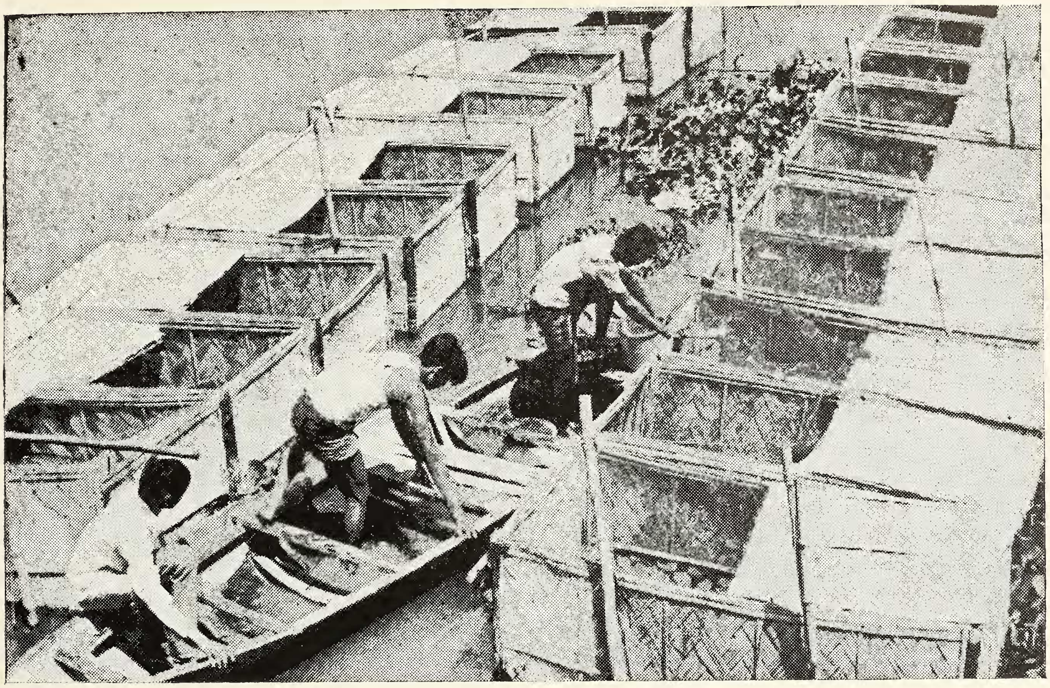
Manual methods of weed clearance are the cheapest and perhaps the best for small water bodies but for larger water sheets and dense infestations, mechanical or chemical methods are necessary. Mechanical methods have been tried in India and several types of weed harvesters developed but the initial high cost coupled with subsequent operational costs have hindered the popularisation of these mechanical devices. Chemical methods thus remain the only solution. Several chemicals have been tried in the course of the last 25 years and effective methods of controlling the noxious floating and emergent weeds like *Eichhornia crassipes. Nymphaea* spp., *Ipomoea carnea, Pistia stratiotes, Cyperus* sp. by use of sodium salt of 2, 4-D without any adverse effect on fish or fish food organisms developed. Aqueous ammonia is equally effective in controlling the submerged weeds. However, use of sodium arsenite, copper sulphate and simazine, though effective, is not generally recommended as it results in gradual accumulation of toxic ions in aquatic animals and proves harmful to human beings in the long run.

8. **Culture of fish food organisms**

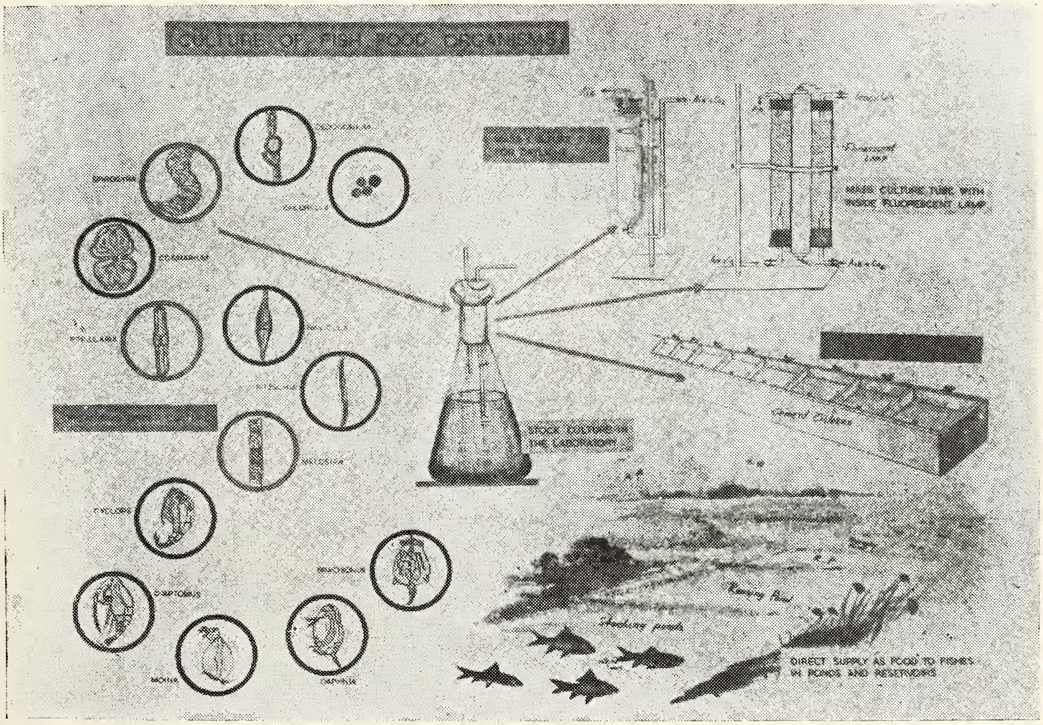
In ponds, fertilisation offers a means of increasing the abundance of fish food organisms. This, however, is a laborious, time consuming and expensive process and may not always result in the abundance of required organisms. Moreover, excessive fertilisation might also cause blooms which are detrimental to fish life in culture ponds. Large scale culture of choice food organisms is, therefore, necessary in a separate environment wherefrom they could be collected and fed to the growing fish. Mass culture of *Chlorella vulgaris* and *Daphnia similis* has been done and a simple and inexpensive method developed using inorganic fertilisers and poultry manure as nutrient source. Freshly-cultured *Chlorella* is used as food for *Daphnia similis.* Mass culture of *Navicula cryptocephala, N. rynocephala* and *Pinnularia acrosphaeria* is done in polythene bags containing water fertilised with urea, single superphosphate and sodium silicate. Culture of *Moina dubia* and *Daphnia lumholtzi* has also been done. It is hoped that this development would result in establishing natural fish food farms.

9. **Freshwater prawn rearing**

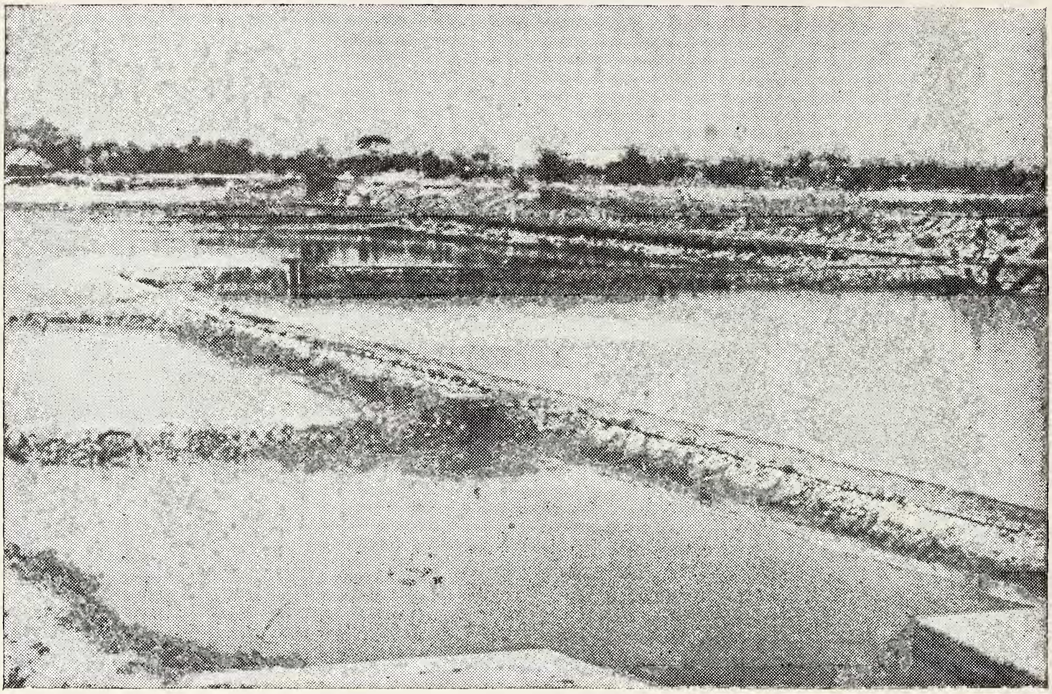
The two important species of freshwater prawns *viz. Macrobrachium rosenbergii* and *M. malcolmsonii* have not yet been systematically cultured in India despite their immense export and domestic market. Both *M. malcolsonii* and *M. rosenbergii* can now be bred in a confined environment. *M. rosenbergii* has recently been bred and reared through its larval stages in the laboratory. The young prawns so produced were reared in ponds at 5,650/ha and a production of 284 kg/ha/4 months obtained. Experiments on propagation and culture of *M. malcolmsonii* at Badampudi



Cage culture has a great future.



A beginning in the establishment of fish food farms.
(*Photos*: Author)



A view of the Brackish water fish farm. Kakdwip (West Bengal).

Selective stocking of mullet pays high dividends.
(*Photos*: Author)

(Andhra Pradesh) and Cuttack (Orissa) have been in progress for some time past. *M. malcolmsonii*, stocked at 50,000 and 75,000/ha has given a production of 212 to 314 kg/ha and 94 to 270 kg/ha respectively in $10\frac{1}{2}$ months. The survival rate has been very poor being 7 to 51%. At Cuttack, however, net productions have ranged from 285-380 kg/ha/yr when stocked at a density of 20,000 juveniles/ha. Attempts are also being made to rear and culture *M. birmanicum* var. *choprai* which is available in considerable abundance in some streams draining into river Ganga in Bihar and Uttar Pradesh.

10. Coldwater fish culture

Not much attention was paid in the past towards the development of hill-streams and upland lakes in India except in a few cases where trouts were introduced either in late last, or early present century. Mirror carp, introduced in certain regions, has well established itself in the lakes but its large-scale propagation for food still remains to be achieved. Establishment of commercial trout farms in the upland areas would not only provide a highly delicious fish to the people of the region but also sport at the same time. This aspect could also be utilised for promotion of tourism and as a source of foreign exchange.

The survival of trout through its various stages of life history was, until recently, very low in the farms of Himachal Pradesh and Kashmir. Experiments conducted on determining causes of mortality have led to the development of techniques for obtaining higher survival. Hatchery practices have now been standardised and the survival from green egg to swim-up fry stage increased to about 89%. Malachite green, used as a fungicide in hatching troughs, results in increasing the survival rate greatly. The mortality in fingerling trout was found to be mainly due to poor feed. Experiments with compound and pelletised artificial feeds, with different levels of crude protein (28-39%), gave a high production and survival rate. A conversion ratio of 1.4 with feed containing 35-39% crude protein and 1.7 with 35% crude protein was noted in rainbow and brown trout respectively. Breeding of brown trout in Uttar Kashi (Uttar Pradesh) was taken up recently and an overall percentage of survival from green egg to fry stage of about 58% achieved. Ensuring high survival rates through use of modern techniques and highly nutritive feed would result in making trout culture a lucrative proposition in the uplands of India. Techniques for breeding and rearing the mirror carp, which result in higher survival rates, have also been developed.

11. Dangers of pesticide pollution

Pisciculture may be treated as an adjunct to agriculture. Large-scale use of pesticides in agriculture is likely to affect fish life in ponds and tanks, beels and jheels and also in rivers/estuaries. The latter form the main source of fish seed of freshwater and brackishwater species. Bio-assay studies on pesticides such as Gammexane, DDT, Folidol, ethyl parathion, Endrin, malathion and Rogor have been conducted using freshwater fishes, zooplankters (rotiger, copepods and cladocerans) and benthic organisms (oligochaetes, chironomids, gastropods and bivalves) as test animals. Investigations on pesticide pollution have indicated that DDT is one of the most dangerous pesticides which gradually accumulates in the body of the fish and even in sublethal concentrations is likely to affect human beings in the long run. The fish itself may die when the accumulated concentrations become lethal. It has to be seen to that while intensive cultivation using high yielding cereal varieties in-